What is claimed is:

I claim:

1. An offshore system for petroleum production, comprising:

a buoyant hull;

a tendon assembly cooperatively engaged with the hull;

a counterweight at a lower end of the tendon assembly to provide tension to the tendon assembly,

an anchor member embedded in a sea floor and having an upper end protruding above the sea floor; and

an engaging member at the lower end of the tendon assembly that telescopingly engages the upper end of the anchor member to restrict lateral movement of the hull and accommodate heave of the hull.

2. The system according to claim 1, wherein the upper end of the anchor member and the engaging member are tubular.

3. The system according to claim 1, wherein the upper end of the anchor member and the engaging member define a chamber that varies in volume as the tendon assembly moves up and down due to heave of the hull, the chamber having a port to draw in and expel sea water to dampen the up and down motion of the tendon assembly.

4. The system according to claim 3, further comprising a check valve in the port that provides a greater flow area for the egress of sea water during downward movement of the engaging

member than a flow area for the ingress of sea water during upward movement of the engaging member.

5. The system according to claim 1, wherein the upper end of the anchor member and the engaging member define a chamber that varies in volume as the tendon assembly moves up and down due to heave of the hull; and wherein the system further comprises:

a port in the chamber to draw in and expel sea water to dampen the up and down motion of the engaging member; and

an adjustable valve over the port for adjusting a flow area through the port.

6. The system according to claim 1, further comprising a plurality of internal risers, each having a separate axis, the internal risers being located in the tendon assembly and extending to the hull for transporting petroleum products between the hull and the sea floor.

7. The system according to claim 1, further comprising :

a plurality of flowlines adapted to be coupled to well equipment on the sea floor and extending to the counterweight; and

a plurality of internal risers joined to upper ends of the flowlines at the counterweight and extending through the tendon assembly to the hull, each of the internal risers having a separate axis.

8. The system according to claim 1, further comprising at least one external riser extending alongside the tendon assembly to the hull, the external riser adapted to be connected to a subsea wellhead at the sea floor.

9. The system according to claim 1, further comprising an anti-rotation device between the engaging member and the upper end of the anchor member for preventing rotation of the engaging member relative to the anchor member.

10. The system according to claim 1, further comprising a plurality of external risers, each of the external risers adapted to be connected to a subsea wellhead at the sea floor, at least some of the external risers engaging the counterweight to prevent rotation of the counterweight relative to the anchor member.

11. The system according to claim 1, wherein the upper end of the tendon assembly is cylindrical, and the system further comprises:

a cylindrical receptacle in the hull that receives an upper end of the tendon assembly, the receptacle having a plurality of circumferentially spaced lugs;

a plurality of keys spaced around the upper end of the tendon assembly for engaging the lugs; and

the tendon assembly secures to the receptacle by relative rotation between the tendon assembly and the receptacle until the keys engage the lugs.

12. The system according to claim 1, wherein the anchor member comprises a tubular piling, and the engaging member comprises a sleeve that slides over the piling.

13. The system according to claim 1, wherein the anchor member comprises a caisson, and the engaging member comprises a piston member that locates within the caisson.

14. The system according to claim 1, wherein the tendon assembly comprises:
an upper riser section extending downward from the hull and a lower tendon section extending downward from the upper riser section, the upper riser section being larger in diameter and shorter in length than the lower tendon section; and the system further comprises:
an upper weight secured to a lower end of the upper riser section.

15. The system according to claim 1, wherein the tendon assembly comprises:
an upper riser section extending downward from the hull and a lower tendon section extending downward from the upper riser section, the upper riser section being larger in diameter and shorter in length than the lower tendon section; and wherein the system further comprises:
a shoulder in a lower end of the upper riser section for supporting an upper end of the lower tendon section; and
a hanger on an upper end of the lower tendon section for landing on the shoulder, the lower tendon section being run through the upper riser section.

16. The system according to claim 1, wherein the tendon assembly comprises:

an upper riser section extending downward from the hull and a lower tendon section extending downward from the upper riser section, the upper riser section being larger in diameter and shorter in length than the lower tendon section; and wherein the system further comprises:

an upper weight at a lower end of the upper riser section; and

a top connector on the upper weight for securing an upper end of the lower tendon section, the upper end of the lower tendon section having a separate axis from an axis of the upper riser section.

17. The system according to claim 1, wherein the tendon assembly comprises:

an upper riser section extending downward from the hull and a plurality of lower tendons extending downward from the upper riser section, the upper riser section being larger in diameter and shorter in length than any of the lower tendons; and wherein the system further comprises:

an upper weight at a lower end of the upper riser section; and

a plurality of top connectors on the upper weight, each securing an upper end of one of the lower tendons to the upper riser section.

18. An offshore system for petroleum production, comprising:

a buoyant hull;

a tendon assembly cooperatively engaged with the hull;

a counterweight secured to a lower end of the tendon assembly to provide tension to the tendon assembly;

a piling embedded in a sea floor and having an upper end protruding above the sea floor; and

a socket at the counterweight that telescopingly slides over the upper end of the piling, defining a dampening chamber that varies in volume as the counterweight moves up and down due to heave of the hull.

19. The system according to claim 18, further comprising a port in the chamber for ingress and egress of sea water.

20. The system according to claim 18, further comprising:
a port in the chamber for ingress and egress of sea water; and
a valve mounted to the port for selectively adjusting a flow area of the port.

21. The system according to claim 20, further comprising a check valve that provides a greater flow area for the egress of sea water from the chamber during downward movement of the engaging member than a flow area for the ingress of sea water during upward movement of the engaging member.

22. The system according to claim 18, further comprising a plurality of internal risers, each having a separate axis, the internal risers being located in the tendon assembly and extending to the hull for transporting petroleum products between the hull and equipment on the sea floor.

23. The system according to claim 18, further comprising an anti-rotation member between the piling and the counterweight for preventing rotation of the tendon assembly relative to the piling.

24. The system according to claim 18, further comprising :

a plurality of flowlines adapted to be coupled to well equipment on the sea floor and extending to the counterweight; and

a plurality of internal risers joined to upper ends of the flowlines at the counterweight and extending through the tendon assembly to the hull, each of the internal risers having a separate axis.

25. The system according to claim 18, further comprising a plurality of external risers extending alongside the tendon assembly, each of the external risers adapted to be connected to a subsea wellhead at the sea floor, at least one of the external risers extending through a passage provided by the counterweight so as to prevent rotation of the counterweight relative to the piling.

26. The system according to claim 18, wherein the upper end of the tendon assembly is cylindrical and the system further comprises:

a cylindrical receptacle in the hull that receives an upper end of the tendon assembly, the receptacle having a plurality of circumferentially spaced lugs;

a plurality of keys spaced around the upper end of the tendon assembly for engaging the lugs; and

the tendon assembly secures to the receptacle by relative rotation between the tendon assembly and the receptacle until the keys engage the lugs.

27. The system according to claim 18, wherein the tendon assembly comprises:

an upper riser section extending downward from the hull and a lower tendon section extending downward from the upper riser section, the upper riser section being larger in diameter and shorter in length than the lower tendon section; and the system further comprises:

an upper weight secured to a lower end of the upper riser section.

28. The system according to claim 18, wherein the tendon assembly comprises:

an upper riser section extending downward from the hull and a lower tendon section extending downward from the upper riser section, the upper riser section being larger in diameter and shorter in length than the lower tendon section; and wherein the system further comprises:

an upper weight at a lower end of the upper riser section;

a shoulder in the lower end of the upper riser section; and

a hanger on an upper end of the lower tendon section for landing on the shoulder, the lower tendon section being run through the upper riser section.

29. The system according to claim 18, wherein the tendon assembly comprises:

an upper riser section extending downward from the hull and a lower tendon section extending downward from the upper riser section, the upper riser section being larger in diameter and shorter in length than the lower tendon section; and wherein the system further comprises:

an upper weight at a lower end of the upper riser section; and

a top connector on the upper weight for securing an upper end of the lower tendon section, the upper end of the lower tendon section having a separate axis from an axis of the upper riser section.

30. The system according to claim 18, wherein the tendon assembly comprises:

an upper riser section extending downward from the hull and a plurality of spaced apart, parallel lower tendons extending downward from the upper riser section, the upper riser section being larger in diameter and shorter in length than any of the lower tendons; and wherein the system further comprises:

an upper weight at a lower end of the upper riser section; and

a plurality of top connectors on the upper weight, each top connector securing an upper end of one of the lower tendons.

31. An offshore system for petroleum production, comprising:

a buoyant hull;

a tendon assembly cooperatively engaged with the hull;

a counterweight secured to a lower end of the tendon assembly to provide tension to the tendon assembly,

a caisson on a sea floor; and

a piston mounted to the tendon assembly and located within the caisson, the piston being upwardly and downwardly movable relative to the caisson due to heave of the hull; and

at least one passage extending from below to above the piston to allow sea water to flow past the piston as the piston moves relative to the caisson for dampening the upward and downward movement.

32. The system according to claim 31, wherein the passage comprises a port through the piston.

33. An offshore system for petroleum production, comprising:

a buoyant hull;

an upper riser section extending downward from the hull;

an upper weight located at a lower end of the upper riser section to apply tension to the upper riser section;

at least one lower tendon section having an upper end coupled to the lower end of the upper riser section, the lower tendon section being substantially longer than the upper riser section and smaller in diameter;

a counterweight secured to a lower end of the tendon assembly to provide tension to the tendon assembly;

a piling embedded in a sea floor; and

a socket at the counterweight that slides over the upper end of the piling and moves up and down relative to the piling due to heave of the hull.

34. The system according to claim 33, wherein the piling and the socket define a chamber that varies in volume as the socket moves up and down, the chamber having a port to draw in and expel sea water to dampen the up and down movement of the socket.

35. The system according to claim 33, further comprising:

a shoulder in the lower end of the upper riser section; and

a hanger on the upper end of the lower tendon section for landing on the shoulder, the lower tendon section being run through the upper riser section.

36. The system according to claim 33, wherein said at least one lower tendon section comprises a plurality of lower tendon sections, and wherein the system further comprises:

a plurality of top connectors on the upper weight for securing the upper ends of the lower tendon sections.

37. A method for mooring a buoyant offshore hull, comprising:

(a) embedding an anchor member in a sea floor;

(b) telescopingly engaging a lower end of a tendon assembly with the anchor member, thereby preventing lateral movement of the lower end of the tendon assembly but allowing upward and downward movement of the tendon assembly;

(c) providing a counterweight at the lower end of a tendon assembly, thereby applying tension to the tendon assembly; and

(d) securing an upper end of the tendon assembly to the hull.

38. The method according to claim 37, wherein step (c) comprises suspending a container at the lower end of the tendon assembly and pumping a heavy liquid material down the tendon assembly to the container.

39. The method according to claim 37, further comprising preventing rotation of the tendon assembly relative to the anchor member.

40. The method according to claim 37, further comprising:

providing a chamber between the piling and the tendon assembly; and

causing sea water to be drawn into the chamber as the tendon assembly moves upward relative to the anchor member, and expelling sea water from the chamber as the tendon assembly moves downward relative to the anchor member.

41. The method according to claim 40, wherein the sea water is drawn into the chamber through a port, and wherein the method further comprises:

varying a flow area of the port to change dampening caused by the drawing in and expelling of sea water.

42. The method according to claim 37, further comprising:

providing a chamber between the piling and the tendon assembly, the chamber having a first flow area for expelling sea water from the chamber and a smaller second flow area for drawing in sea water into the chamber;

causing sea water to be drawn into the chamber through the first flow area as the tendon assembly moves upward relative to the anchor member, and expelling sea water from the chamber through the second flow area as the tendon assembly moves downward relative to the anchor member.

43. The method according to claim 37, wherein step (d) comprises:

positioning the upper end of the tendon assembly below sea level;

floating the hull over the upper end of the tendon assembly; then

ballasting the hull until it lowers into engagement with the upper end of the tendon assembly.

44. The method according to claim 37, wherein steps (b) and (d) comprises:

providing the tendon assembly with an upper riser section and a lower tendon section, securing the upper riser section to the hull, then lowering the lower tendon section through the upper riser section.

45. The method according to claim 37, further comprising after step (d) flowing petroleum products through the tendon assembly between equipment at the sea floor and on the hull.